RAW MATERIALS

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RAW-MATERIAL RESOURCES OF THE URAL REGION

N. F. Solodkii[1] and M. N. Solodkaya[1]

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Promising deposits in the Ural Region that are suitable for use in the ceramics industry in the Urals and in other regions of Russia are considered.

The Ural region occupies a leading place in the Russian Federation in richness and variety of ceramic raw materials.

The deposits of high-melting clays identified and currently mined in the Urals are the largest in Russia. So far they are suitable only for production of refractories and building ceramics. Some prospects for identifying clays for fine-ceramics production exist in the Chelyabinsk, Orenburg, and Perm Regions and in Bashkiria.

The following deposits can be of special interest for further study of argillaceous materials of the Urals:

– Novo-Ivanovskoe (Bashkiria): high-melting plastic clays characterized by a low content of coloring oxides; they sinter at low temperatures within a wide temperature range; additional prospecting of this deposit is required;

– Gorodishenskoe (12 km from Kartaly station on the South-Ural Railway): high-melting highly plastic clays, with a low content of pigment oxides; they sinter within the temperature range of 1200 – 1300°C and have a white crock at 1300°C; additional surveying is required;

– Astaf'evskoe (Chelyabinsk Region): high-melting clays of kaolinite and quartz-kaolinite mineral composition;

– Kremenkul'skoe (12 km from Chelyabinsk): the clays have high refractoriness and by chemical composition are suitable for fine-ceramics production; the deposit has not been prospected but is worth detailed investigation.

In the 1930s geologists in the Urals found deposits of purest halloysite mineral without any impurities near Aidyrlya Station (Orenburg Region). However, no one showed interest in that deposit. The chemical composition of halloysite has nearly the same ratio of alumina and silica ($Al_2O_3 : SiO_2$) as kaolinite, but contains nearly twice as much water.

Deposits of alkali kaolins situated in the Chelyabinsk Region merit attention as an integrated material.

Numerous deposits of high-quality kaolins suitable for fine-ceramics production are currently outside the territory of Russia. The most promising and ready for use in Russia is kaolin from the Zhuravlinyi Log deposit (Chelyabinsk Region), which has been widely tested in production of household and electrotechnical porcelain. The results of the experiments performed and prototype industrial production show that by its mechanical and electrophysical parameters, the material is suitable for production of household and electrotechnical porcelain. Thus, the problem of replacing imported kaolin with a Russian material is partly solved.

The best feldspar and pegmatite deposits are concentrated in Karelia and the Kola Peninsula.

The Ural Region also has deposits of feldspar, pegmatites, and their substitutes, whose reserves in most cases are little studied. Ural pegmatites consist mostly of potassium feldspars: microcline and orthoclase-perlite. Investigations carried out earlier at the Research Institute of Porcelain (NIIF) in St. Petersburg established that the quality of Ural pegmatites in their natural form unfortunately does not meet the requirements of porcelain production. Within the framework of the development of Russian science and industry it is expedient to provide for construction of concentration facilities at mining enterprises and mines and equip them with modern dressing machinery and technologies, using the practice of supplying production enterprises with conditioned materials, which is a common practice abroad.

The main sources for this type of materials in the Ural Region are the Vishnevogorskoe, Malyshevskoe, Shershnevskoe, Kremenkul'skoe, and Rezhik deposits.

Among the prospected and studied deposits of feldspar and pegmatite, the Vishnevogorskoe deposit (18 km from Mauk station) should be put in first place.

More than 90% of the mined pegmatite is wasted due to a high content of iron and titanium oxides. Natural pegmatite

[1] South-Ural Porcelain Works JSC, Russia.

lumps have gray and pink-gray colors. Crushed and fused pegmatite produces a greenish foamy melt with dark spots. Microcline-porite prevails in the pegmatites. The presence of nepheline sienite (up to 9%) is detected. Aegirite impurities are present in the form of single crystals and agglomerations.

The Vyshnevogorskoe Mining Administration at present performs partial concentration of tailings which are later supplied to the glass and abrasive industries in the Urals. The material contains up to 0.5% Fe_2O_3 with an alkali ratio ($K_2O + Na_2O$) close to unity, and therefore it is not suitable for porcelain production, especially for insulating porcelain.

The Vishnevogorskoe Mining Administration produces feldspar and nepheline-feldspar concentrate of grades PShS-0.30-20, PDhS-0.50-20, IPShS-0.30-21. These products are used by over 70 companies in the Russian Federation and the CIS countries. This concentrate is one of the main components in the production of window and plate glass and is also used in the production of color and black-and-white TV tubes in the electrovacuum industry, medical tools and laboratory ware, welding electrodes in the production of abrasives, and glaze in ceramics.

The feldspar and nepheline-feldspar concentrates do not have analogs in Russia or abroad, since they are distinguished for their high and stable content of aluminum (at least 20%), potassium (5 – 6%), and sodium (7 – 8%) oxides. Using these concentrates makes it possible to produce a glass batch that generates a substantial amount of melt in sintering while providing high purity and transparency of products. Use of the concentrate produces up to a 30% savings in the soda consumed in batch preparation, depending on the type of product, without deterioration of product quality.

The Malyshevskoe Mining Administration (15 km from the town of Asbest) has a modern dressing factory that produces muscovite-mica and feldspar concentrates.

The feldspar is represented by microcline and albite, the free-quartz content being not more than 10%, potassium and sodium oxides at least 11%, and aluminum oxide 18.0 – 19.5%. The ratio of potassium oxide to sodium oxide in the concentrates (by agreement with the consumer) can be below 0.6 and up to 1. The iron oxide (Fe_2O_3) content can be below 0.2 and up to 0.5%.

This factory has a chance of producing quartz-feldspar concentrates with a total content of potassium and sodium oxides of 7.5 – 8.5% and free quartz not more than 40%. The content of iron and potassium is equal to that of feldspar concentrates.

The production capacity allows for producing up to 120,000 tons of feldspar concentrates per year, which is used in production of faience, majolica, ceramic construction materials, and glass.

In the Alapaevsk group of feldspar deposits, Severnaya Myl'nitsa, Alabashskoe, Tysyachnitsa, and Vatikha are of special interest. The robust Vatikha deposit is yet not prospected in detail.

Feldspar can be replaced by granite from the Rezhik deposit (Sverdlovsk Region). Concentrated granite is an adequate substitute for feldspar in the production of porcelain and semiporcelain sanitary ware.

A possible source for high-potassium material can be kaolinized rock and pink granites from the Kremenkul'skoe granite rock mass (Chelyabinsk Region).

The Kremenkul'skoe rock mass consists of pink leucocratic granites bedded among granodiorites. The most common are large- and medium-grained granites containing mostly pink potassium feldspar (49%), grayish-white plagioclase (23%), and quartz (25%).

The Shershnevskoe pink granite deposit located not far from Chelyabinsk contains three granite varieties: gray porphyritic granites and fine- and medium-grained pink granites bedded in quartz diorites.

The most promising for ceramic production are fine- and medium-grained pink granites represented by massive uniformly grained rocks of brownish-pink to light-pink shades and of fully crystalline, sometimes porphyritic, less frequently microaplite or micropegmatite structure.

The rock contains potassium feldspar (mostly lattice microcline, 35 – 40%), plagioclase (from albite-homeoglase to homeoglase-andesine, 25 – 30%), and quartz (35 – 40%). Biotite occurs in nature in the form of single small scales or agglomerations (not more than 1%). Accessory minerals in small quantities include zircon and sphene, and secondary minerals include muscovite, chlorite, sericite, and pyrite.

The practical experience of the 1960s, when the South-Ural Insulator-and-Armature Factory was using pink granites in porcelain mixtures to produce high-voltage insulators, is not currently in use. Compared to pegmatite, granite has a more stable composition and in those years this material made it possible to produce insulators with better electromechanical parameters.

It has been suggested that high-quality microcline pegmatites can be identified in sufficient quantities in the Malyshevskoe deposit (Sverdlovsk Region) and the Kochkarskii district of the Chelyabinsk Region. The first samples of microcline pegmatites taken in the Kochkarskii district confirm this. The mass content is as follows (%): 64.01 – 72.61 SiO_2, 15.35 – 20.59 Al_2O_3, 0.08 – 0.21 Fe_2O_3, 0.08 – 0.28 CaO, 0.02 – 0.16 MgO, 7.04 – 12.48 K_2O, 0.46 – 3.12 Na_2O, 0.65 – 2.44 calcination loss.

Substantial resources of high-purity aplite rocks have been identified in the Kochkarskii district as well.

Production of fine household ceramics should use mainly vein quartz, but due to the shortage of this material, many factories are forced to use high-grade quartz sand, quartz waste from kaolin elutriation, pulverized quartz materials, siliceous materials, etc., which to a large extent reduce the translucence of the final product.

The Urals are rich in vein quartz, quartz sands, quartzites, and marshalite. However, these materials have not yet been investigated in detail as ceramic materials. The purest vein quartz materials are located in the Bilimbaevskii, Nevianskii, and Zlatoustovskii districts. Their silica content is 99%, and the sum of the sesquioxides is up to 0.26%.

To substitute for the quartz sand from the Ul'yanovsk Region, it is convenient to use sands from the Malyshevskoe, Vozdvizhenskoe, Kyshtymskoe, Svetlinskoe, Iriklinskoe, and Kulikovskoe deposits and Kremennaya Mountain and pulverized quartz (marshalite) from the Bolotovskoe, Nagaibakskoe, Lysaya Gora, Arkhangel'skoe, and other deposits.

Along with further study of traditional types of materials, it is necessary to study new raw materials as well: talcs, pyrophylites, kyanites, nepheline-sienites, sericite schists, etc. These materials substantially expand available resources and make it possible to produce both traditional products by standard technologies and new types of ceramics, including fine stone-cast products, refractory kitchen ware, semiporcelain, and majolica and bring the raw materials closer to the production facilities. The use of new types of materials will reduce production costs, improve product quality, and expand the product range.

Among alumina-bearing materials that merit special attention is the Chistogorskoe deposit of quartz-pyrophylite schists (Chelyabinsk Region). Its chemical composition (%) is: 67.29 SiO_2, 20.94 Al_2O_3, 1.27 Fe_2O_3, 0.59 TiO_2, 0.29 CaO, 1.64 MgO, 4.34 calcination loss.

Of great interest is the Uiskoe deposit (Chelyabinsk Region) containing a mineral similar to pyrophyllite, which has the following chemical composition (%): 44.40 SiO_2, 1.26 TiO_2, 40.40 Al_2O_3, 0.56 Fe_2O_3, 0.81 CaO, 0.31 MgO. The fire resistance of the material is 1540°C, the water absorption prior to firing is 0.66%, after firing 0.0%, and the content of Al_2O_3 in the calcined material is 42.13%.

Tailings rocks of Kul-Yur-Tau sericites (Bashkiria) can be of special interest for ceramic production and have the following chemical composition (%): 46.10 SiO_2, 46.58 ($Al_2O_3 + TiO_2$), 0.61 Fe_2O_3, 0.48 CaO, 1.39 MgO, 6.95 K_2O, 2.06 Na_2O, 6.59 calcination loss.

Another interesting material is quartz-pyrophillite rock from the Gaiskoe deposit (Orenburg Region) with the following chemical composition (%): 78.04 SiO_2, 16.96 Al_2O_3, 0.10 Fe_2O_3, 0.95 CaO, 0.20 MgO, 0.33 K_2O, 0.30 Na_2O, 2.70 calcination loss. A special feature of this material is its mineral composition (%): 50 pyrophyllite, 45 quartz, 5 sericite.

At least 20 deposits of minerals of the sillimanite group $Al_2O_3 \cdot SiO_2$ (kyanite) are concentrated in the Urals. A rough estimate of their resources can be used to infer the expediency of using these ores in the refractory and ceramics industry.

The Karabashskoe deposit is the best studied for the types of ores and the bedding conditions. The average content of disthene in the ores is 21.2%. The mineral composition of the ores is simple: quartz + disthene + muscovite (magnetite, pyrite, rutile up to 3%).

The kyanite schists in the Borisovskoe deposit contain up to 26% kyanite.

The Mikhailovskoe deposit represents a continuous strip of kyanite-containing schists. The average content of kyanite in the ore is up to 5%.

The Malokaslinskoe deposit contains two schist lenses. The southern lens has a higher content of kyanite (up to 15% on the average). The ore is loose and argillaceous. The northern lens is loose argillaceous rock with single crystals and clusters of kyanite. In chemical composition, the SiO_2 content in Ural kyanites ranges from 28.2 to 54.4%, and the Al_2O_3 content from 44.4 to 62.9 %.

Tailings rocks of the town of Plasta contain kyanite resources that are of industrial interest.

The Abramovskoe site (Soskovsko-Abramovskoe bed) is promising both for setting up production of concentrated kyanite and for prospected raw-material resources that can be increased substantially. The Sosnovskoe site is characterized by a decreased content of alumina in the kyanite (41.0 – 41.5%).

The kyanite ores of the Malo-Brusyanskoe site have a lens-shaped form 100 – 600 m long, up to 60 m wide, and 10 – 50 m thick. They are overlapped by eroded rocks containing loam with quartz fragments and kyanite inclusions. The kyanite mineralization is related to quartzites, mica-quartz schists, and amphibole gneiss.

Additional prospecting is needed to estimate and identify the kyanite resources, and technological tests are required to assess the obtained concentrates for production of refractories and fine ceramics.

Until recently, the Ural Region was not counted among the territories promising for porcelain stone deposits. However, studies carried out by scientists from the Komy Scientific Center of the Ural Branch of the Russian Academy of Sciences in the Northern Urals revealed some analogs of porcelain stones among metasomatic modified varieties of trachiliparites and liparites, which are present in the composition of commonly found Late Cambrian and Early Pamozoic vulcanogenic strata.

An analysis of the mineral and chemical composition of acid apovolcanite in the Northern Urals made it possible to distinguish two main types of porcelain stones: Kapkanovozhskii and Sivyaginskii. Kapkanovozhskii porcelain stones are dense schistoid fine-grained light-colored rocks of white, yellowish, and bluish shades, often with a retained quartz-porphyric structure. The rock composition is sericite-quartz or pyrophyllite-sericite-quartz.

The Syvyaginskii variety of the porcelain stone consists of fine-grained bluish-greenish-gray and cream-colored rocks that have a nearly monomineral potassium feldspar composition. Quartz and sericite are present in small quantities.

The western slope of the Urals contains volcanic formations of alkali high-potassium porcelain stones. Such volcanites are virtually unknown in geosinclinal (oceanic and island-arc) volcanogenic formations. Potassium-sodium liparites with a ratio $K_2O : Na_2O$ on the average of about 1.8 are found in the Urals only in the Uchalinkoe zone of the Ulu-Tau formation, whereas usually $K_2O : Na_2O < 1$. On the other hand, alkali potassium and ultra-potassium volcanites are rather frequently encountered in formations whose origi-

TABLE 1

Mineral	Content, %	
	of mineral in weathering crust (talcites)	in primary rocks (talc stone)
Talc	77.4	54.5
Magnetite	5.0	5.4
Iron hydroxide	6.1	1.4
Chlorite	5.8	1.5
Quartz	3.3	0.2
Mica	0.3	0.2
Carbonates:		
calcium	–	1.1
dolomite	–	1.3
Ankerite, siderite, brinerite, magnesite	0.1	31.8

nation accompanied activation processes of the rather mature continental crust.

To this group of formations containing porcelain stone deposits, one can refer liparites from Konstantinov Kamen' mountain, Khakharem-Pe ridge, and Berezovaya mountain in the Far North of the Polar Urals, subvolcanic intrusions of the Pogurey River and Kok-Pela River heads, and more ancient liparites in the upper part of the Khalmer'yu River, the right bank of the Torgovaya River, and the Verkhnesereginskii (Bilimpaevskii complex) and Nyazepetrovskii districts (Chelyabinsk Region).

The western slopes of the Ural Mountains have abundant Middle Riphean vulcanogenic-sedimentary layers (Maskakskoe suite and its contemporary analogs). The volcanites of this layer can be referred to a contrasting basalt-liparite formation with an evident subalkali trend. A sampling of tests of subalkali acid volcanites from this formation points to an abundance of trachyliparites with a ratio $K_2O : Na_2O \geq 4.0$. The presence of similar zones is identified in the Bashkirian anticlinorium. There are data on local manifestations of porcelain stones in Bashkiria, upper parts of the Ural River, the Emanzhelinskii and Kushanakskii districts (Chelyabinsk Region), and the left bank of the Pyshma River (Sverdlovsk Region).

Thus, it can be stated that the Ural Region is a new geological province of porcelain stone.

The shortage of high-quality talc in many sectors of industry in Russia and in foreign countries can be overcome by mining this material in the Kochkarskii geological district.

The talc bedding thickness is 55 m, and according to a geophysical survey it reaches 90 m. Prospectors have traced the talc bed up to the distance of 2 km. It is assumed that the bed is longer than that. The estimated resource is 12 – 15 million tons of high-quality talc.

The primary talc metasomatites are usually schists and sometimes massive varieties containing veins of porphyric carbonate detachments. As a result of studying 18 clear sections, it was found that this rock consists of fine-scale talc aggregates with clusters and single grains of carbonates that form pseudoporphyric inclusions. Their intergrowth with talc is slight. The talc content in the metasomatites varies from 48.0 to 61.4% and on the average amounts to 54.5%. The mineralogical composition of weathering crusts and primary talc metasomatites is presented in Table 1.

The above data indicate that exogenic processes result in leaching of carbonates, which reduces the carbonate content in the talcites by 36.7%.

As a result of flotation concentration, concentrated talc with the following parameters was produced: residue insoluble in HCl 90%, Fe_2O_3 content 2.3%, calcination loss 5.6%, whiteness 68%. In bleaching, the talc whiteness increases to 86%, and the Fe_2O_3 content decreases to 0.4%.

There are reasons for continuing technological investigations and studying in detail the talc ore resources in the Chempalovskoe deposit.

Thus, a rich mineral basis exists in the Urals that is suitable for ceramic production, and many factories of the Urals can be supplied with local materials. Virtually all Ural deposits are accessible to mining and are located in economically developed territories and near railways and paved roads.

It appears expedient to organize surveying and prospecting activities in order to fully prospect the resources, determine their suitability, develop technologies for raw-material concentration, and construct state-of-the-art concentration facilities. Completion of such activities ought to be provided for in the framework of the national program for development of industry in Russia.